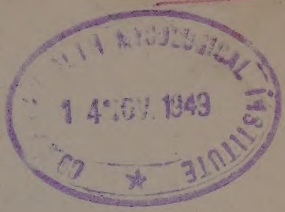


UNIVERSITY OF MAINE

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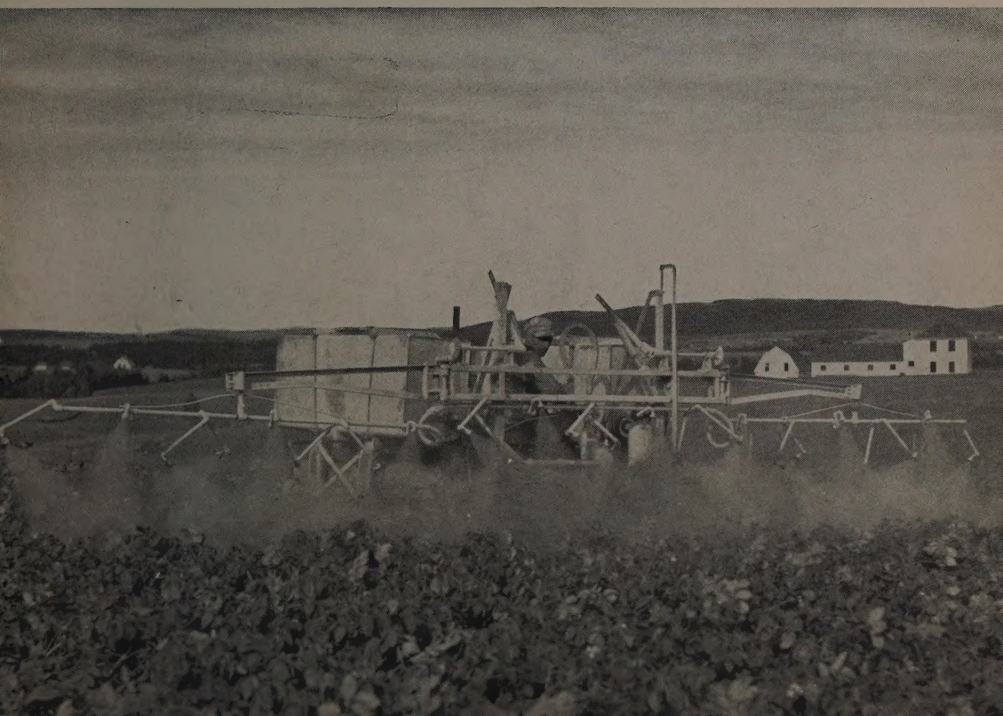
# Control of Late-Blight Tuber Rot

REINER BONDE AND E. S. SCHULTZ



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BULLETIN 471

# CONTROL OF POTATO LATE-BLIGHT TUBER ROT

REINER BONDE[1] AND E. S. SCHULTZ[2]

## INTRODUCTION

Losses from late-blight tuber rot occur nearly every year in the concentrated potato growing areas of Maine and in some years the loss is very large. A survey made in 1941, showed that approximately 10 per cent of the 1941 potato crop of Aroostook County was destroyed by late-blight tuber decay (*1*,[3] p. 304). A similar survey conducted in 1944, in which 110 potato storage bins were carefully examined, revealed an average loss of 16 per cent of the total 1943 crop harvested (*6*). Large losses also were observed by the authors in the 1945 and 1947 crops from both the northern and central potato growing areas of Maine. The amount of tuber rot varied from a trace in some storage bins to 75 per cent or more in others. The large losses reported here occurred in spite of the fact that the potato growers carried out rather intensive spraying programs for the control of this disease.

This bulletin summarizes the authors' attempts to determine the primary reasons for the large amounts of late-blight tuber infection which sometimes occur in Maine. The results demonstrate that digging the potato crop while the foliage is green and infected with late blight is an important factor in increasing the amount of tuber rot. Killing the infected foliage with herbicides and growing resistant varieties are discussed as control measures. This report supplements previous summaries by Bonde and Schultz (*4*) and by Bonde (*5*) concerning the use of herbicides for the control of late-blight tuber rot.

## SPRAYING AND DUSTING WITH FUNGICIDES TO CONTROL LATE-BLIGHT TUBER ROT

Thorough applications of spray or dust fungicides, which prevent foliage infection, are recommended for the control of late-blight tuber rot. There are a number of newer fungicides in addition to Bordeaux

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[3] Italic numbers in parentheses refer to Literature Cited.

mixture that are effective in controlling the spread of late blight. The foliage should be kept covered with the fungicide, requiring applications every week or at 10-day intervals depending on the weather conditions. Such applications should start early in the season and be continued until the plants are dead.

However, it has often been observed in Maine that the tubers from fields in which the tops have been killed completely by late blight early in the season generally have no decay, or only a slight amount, in the storage bin. On the other hand, the percentage of tuber decay often is large in fields with little late blight on the foliage and where the plants remain green until frost. Complete control of foliage infection often is difficult to obtain with applications of fungicides, and a little infection may cause a great deal of tuber decay if disseminated to the tubers while the crop is being harvested.

## TUBER ROT CAUSED BY DIGGING WHILE THE FOLIAGE IS PARTLY GREEN AND INFECTED WITH LATE BLIGHT

Tuber rot may occur when the late-blight spores are washed by rain water from the green potato plants into the soil where they infect the potatoes before they are dug. This method of tuber infection in Maine is more prevalent in the darker Washburn loam type of soil than in the better potato growing soil known as Caribou loam. However, the writers are of the opinion that most of the tuber rot found in Aroostook County, Maine, is from infection that occurs while the crop is being harvested. The viable spores of the late blight fungus which develop on the green leaves and stalks (see Figures 1 and 2) come in contact with the potatoes during the process of digging, but the rot is not apparent until after the potatoes have been in storage for a week or more or have been shipped to the market.

During the season of 1941 an inspection was made of the potato bins of two growers who had experienced large losses from late-blight rot. These growers had harvested their choice seed stocks rather early in the season from fields that appeared to be free from late blight and they thought the crop to be in a healthy condition. Several weeks later, when the bins were examined, 50 to 60 per cent of the tubers were infected with late-blight.

Further investigations revealed that similar losses were not uncommon, especially when the crop was sold on the early market, when the main crop was harvested before frost, or when seed stocks were

FIGURE 1. A partially dead potato field just prior to time of harvest. The plants in such fields may have traces of late blight on the leaves and stems which infect the tubers while the crop is being dug.

harvested early in the season for the control of virus diseases.[4] In all cases it appeared that the potatoes were contaminated with spores while being dug and the rot was not apparent until the tubers had been in storage for several weeks (see Figure 3).

This information led to a renewed study to determine the factors that may contribute most to the control of late-blight tuber rot as it occurs in Aroostook County. Experiments were conducted during the four-year period from 1942 to 1945 to get more information regarding the effect of digging the potato crop before the foliage is completely dead on the amount of tuber rot that develops in the bin.

The Green Mountain and Katahdin varieties were used for these studies. The fields were sprayed and the disease was kept under fairly good control. Some late blight, however, was permitted to develop late in the season.

A part of each field was harvested each year after September 15 when the foliage was mature and dying but still possessed some infected green stalks and leaves. Other parts of the same field were harvested at later dates when the plants were completely dead, having been killed by frost. The potatoes were placed in commercial storage immediately

[4] One out-of-State grower informed the writer by correspondence that he lost four carloads of potatoes in 1942 because the potatoes decayed in transit from late-blight infection. Large losses also have occurred in truck and rail shipments of potatoes from Maine where potatoes infected with blight were dug while the foliage was still green.

FIGURE 2. Potato leaf infected with the late blight fungus. During damp weather the spots will produce a whitish mildew containing numerous spores on the lower surface. These spores may infect the freshly dug tubers.

after being harvested and were examined for late-blight tuber decay after a period of approximately eight weeks.

The data in Table 1 show that the amount of late-blight tuber rot in the crop that was harvested while the foliage was green, varied from 10 per cent in 1945 to 53 per cent in 1944. In contrast the potatoes

FIGURE 3. Potato tubers, one healthy (lower left) and three infected with the late blight fungus. Such decay occurred when freshly-dug tubers of susceptible varieties came in contact with the infected potato foliage in the process of harvesting.

that were dug after the foliage had been killed by a frost ranged from no rot in 1942 and 1945 to 6 per cent in 1944.

According to Murphy (*10*), Jensen in 1887 called attention to the

TABLE 1

*Comparison of Late-Blight Tuber Rot in Potatoes from Plots in the Same Field Harvested before and after the Foliage Was Killed by Frost*

| Treatment | Year and amount of tuber decay[1] | | | |
|---|---|---|---|---|
| | 1942 | 1943 | 1944 | 1945 |
| | Per cent | Per cent | Per cent | Per cent |
| Plots harvested before foliage was completely dead | 20 | 48 | 53 | 10 |
| Plots harvested after foliage had been killed by frost | 0 | 4 | 6 | 0 |

[1] Average of eight 50-pound samples for each treatment after being in storage for approximately 8 weeks

danger of digging the crop while any green foliage remains on diseased plants. Murphy concluded from field experiments conducted in Canada and Ireland, that the bulk of the infection that develops in storage is contracted when the potato crop is dug. Furthermore Jones and Morse (*7, 8, 9*) in 1902-1904 stated that in Vermont it is best to delay digging when there is danger of rot.

The data obtained in Maine confirm the conclusions of Murphy and those of Jones and Morse. The fact remains, however, that many farmers in Maine, and probably elsewhere, continue to harvest their potato crop while the foliage is partially green and while late-blight infection is present.

## CONTROL BY KILLING THE TOPS WITH HERBICIDES

The question arose as to whether the amount of tuber rot can be reduced by killing the potato tops with an herbicide. In 1943 and 1944 parts of a field of Katahdin potatoes were killed by being sprayed with a solution of Sinox and ammonium sulphate. The plants in adjacent parts of the same fields were not killed and their tubers were used for comparisons regarding the amount of tuber decay. The tubers from the treated and the control plots were harvested and put into storage at 2- and 10-day periods after the herbicide had been applied. The potatoes were examined for late-blight tuber rot after a storage period of approximately six weeks.

The data in Table 2 show that late-blight tuber rot can be greatly reduced by killing the infected potato tops with an herbicide. In 1943, 40 per cent of the tubers harvested from the green plots developed storage rot, whereas only 3 per cent rotted when harvested 10 days

TABLE 2

*Effect of Killing Tops with an Herbicide on the Amount of Late-Blight Tuber Rot*

| Treatment | Amount of tuber decay[1] | |
|---|---|---|
| | 1943 | 1944 |
| | Per cent | Per cent |
| Tubers dug while foliage was partly green | 40.0±2.8 | 54.0±18 |
| Tubers dug 2 days after tops were killed by spraying[2] | 11.0±1.9 | 13.6±15 |
| Tubers dug 10 days after tops killed by spraying[2] | 3.0±0.6 | 3.0±0.9 |
| Tubers dug after tops were killed by frost | 5.9±0.9 | 0±0 |

[1] Average of eight 50-pound samples for each treatment after being in storage lockers for six weeks.

[2] Plants killed by spraying with spray mixture of 2 gallons Sinox and 10 pounds of ammonium sulphate in 100 gallons of water applied at the rate of 140 gallons per acre. Sinox manufactured by Standard Agricultural Chemicals, Inc., Hoboken, N. J.

after the plants had been killed. In 1944, by killing the tops and digging 10 days later, tuber rot was reduced from 54 per cent to 3 per cent. Other experiments have shown that any of the herbicides used as potato top killers will destroy the late-blight fungus infection if toxic enough to destroy the plants.

## CONTROL BY SPRAYING WITH COPPER SULPHATE SOLUTION PRIOR TO DIGGING

Some growers have found that the amount of late-blight tuber decay occurring in storage may be reduced by spraying the foliage with a concentrated copper sulphate solution just prior to digging. This procedure, however, does not completely kill the potato foliage that interferes with harvesting. This treatment also does not allow enough time for the skin or periderm of the tubers to harden which results in much bruising and in a poor appearance of the crop.

In 1947, an experiment was conducted for the purpose of obtaining more information regarding the value of spraying potato foliage with a copper sulphate solution for the control of storage decay. Parts of an infected field of Katahdin potatoes were sprayed with a concentrated copper sulphate solution and adjacent parts of the same field were sprayed with a solution of sodium arsenite (Handy Killer). The potatoes from the treated and the untreated controls were harvested and placed in storage at 2- and 10-day intervals after the spray treatments. The

TABLE 3

*Late-Blight Tuber Rot as Affected by Spraying Tops with Copper Sulphate Solution and with Sodium Arsenite Herbicide*

| Treatment | Per cent tuber decay[1] |
|---|---|
| Control tubers dug while foliage was green and infected | 43 |
| Tubers dug 2 days after foliage was sprayed with copper sulphate solution[2] | 6 |
| Tubers dug 10 days after foliage was sprayed with copper sulphate solution[2] | 26 |
| Tubers dug 2 days after foliage was killed with a sodium arsenite solution (Handy Killer)[3] | 3 |
| Tubers dug 10 days after foliage was killed with a sodium arsenite solution (Handy Killer)[3] | 4 |

[1] Tuber rot from two 50-foot rows for each treatment after storage of approximately six weeks.
[2] Thirty pounds of copper sulphate dissolved in 100 gallons water applied at rate of 140 gallons per acre.
[3] Four quarts Handy Killer containing 23.5 per cent sodium arsenite in 100 gallons water applied at rate of 140 gallons per acre. Handy Killer manufactured by Ralph Adams, Lakeville, New Brunswick, Canada.

FIGURE 4. Late-blight infection in potato stems. The late-blight organism may remain alive inside of these lesions during periods of dry weather and produce numerous spores when the conditions become favorable. These spores infect the potatoes when the crop is dug.

potatoes were examined for late-blight tuber rot after being in storage six weeks.

Table 3 shows that the amount of late-blight rot was reduced by spraying the infected potato foliage with a solution of copper sulphate. There was 43 per cent tuber rot in the untreated controls compared with 6 per cent decay when the crop was sprayed with the copper sulphate solution and harvested two days later. However, there was 26 per cent tuber decay when the crop was dug 10 days after it had been sprayed with copper sulphate. In the same experiment there was 3 and 4 per cent tuber rot respectively when the foliage was killed with sodium arsenite and the crop was dug 2 and 10 days after having been killed with sodium arsenite.

Spraying with the copper sulphate solution killed the viable spores that were present on the infected plants and thus prevented the tubers from becoming infected when harvested two days after the spray treatment, but did not kill the late-blight organism inside of the living stems and leaves (see Figure 4). Rains removed the spray residue on the infected foliage and a new crop of viable spores developed when the moisture and temperature conditions were favorable. These spores infected the potato tubers during the process of harvesting the crop.

This experiment demonstrates that spraying infected fields with a concentrated copper sulphate solution may reduce the amount of late-blight tuber rot, if the crop is harvested soon after the fungicide has been applied. It should be emphasized that the late-blight organism inside of the living plant is not readily killed with a copper sulphate spray and may still cause tuber infection under certain conditions.

## CONTROL BY MECHANICAL DEFOLIATION OF INFECTED TOPS

A number of farmers in Maine have used a mechanical defoliation machine (rotobeater) to destroy the potato foliage prior to the digging operation.[5] The question arose as to whether the amount of late-blight tuber rot in the storage bin could be reduced by the use of this type of equipment.

In 1948 the plants in parts of an infected Green Mountain and Katahdin potato field were destroyed with the rotobeater and the amount of tuber rot that developed was compared with that which developed in tubers from parts of the same field that had been killed by spraying with a solution of Sinox General herbicide. Other parts

[5] The machine destroys the foliage by beating and mascerating the foliage. Manufactured by the Olsen Manufacturing Company, Boise, Idaho.

of the same field including both varieties were first defoliated with the rotobeater and then sprayed with Sinox General and Diesel fuel oil to kill any remaining blighted foliage.

Table 4 shows that destroying the infected foliage with the rotobeater reduced significantly the amount of tuber rot in both varieties. Killing the infected foliage with the rotobeater reduced the late-blight rot to approximately 2 per cent in each case except for the Green Mountain variety as dug on August 27, two days after the treatment. Because of the satisfactory control secured with the rotobeater the additional treatment with Sinox General and Diesel fuel oil did not give a significant reduction in late-blight rot except for the Green Mountains referred to above. The control of late-blight rot with the rotobeater alone was nearly as satisfactory as killing the vines with Sinox General and Diesel fuel oil. However, it has been observed by the writers in other experiments that the rotobeater sometimes does not completely kill the infected foliage. Under such conditions it would be advisable to spray with an herbicide after the rotobeater treatment.

TABLE 4

*Effect of Killing Infected Potato Foliage with a Rotobeater on the Amount of Late-Blight Tuber Decay*

| Treatment[1] | Percentage late-blight rot[2] | | | |
|---|---|---|---|---|
| | Dug August 27 | | Dug September 1 | |
| | Green Mountain | Katahdin | Green Mountain | Katahdin |
| Untreated controls | 21.1 | 7.9 | 9.9 | 12.8 |
| Rotobeater but no chemical herbicide | 6.5 | 2.1 | 1.6 | 1.6 |
| Rotobeater and remaining vines killed with Sinox General and Diesel fuel oil[3] | 0 | 1.4 | 1.4 | 1.3 |
| Vines killed with Sinox General and Diesel fuel oil[3] | 1.0 | 2.4 | 0.2 | 0.8 |

L.S.D. at 5 per cent level is 1.82 per cent.
L.S.D. at 1 per cent level is 2.47 per cent.
[1] Applied August 25.
[2] Average of five lots of tubers of approximately 50 pounds each for each treatment.
[3] Two pints Sinox General and 3 gallons Diesel fuel oil in 100 gallons water applied at rate of 140 gallons per acre. Sinox General is manufactured by Standard Agricultural Chemicals, Inc., Hoboken, N. J.

## CONTROL BY GROWING RESISTANT VARIETIES

Probably the best method of controlling late-blight tuber rot is by growing resistant or immune varieties. Progress has been made in Maine in the development of highly resistant varieties that possess good marketing qualities (*2* and *3*).

Table 5 compares the amount of tuber rot that occurred from natural infection in a number of susceptible and resistant varieties grown at Aroostook Farm over the period from 1936 to 1947 inclusive. Blight was permitted to develop in the experimental plots, and the crop was harvested by hand digging before the foliage had been killed by frost, thus affording favorable conditions for the development of late-blight tuber rot.

The data show that the susceptible Green Mountain and Katahdin varieties developed a considerable percentage of late-blight rot when harvested under conditions favorable to the fungus. In contrast the resistant Sebago, Kennebec, and Saranac varieties and seedling 336-18 developed no rot under the same conditions (see Figure 5).

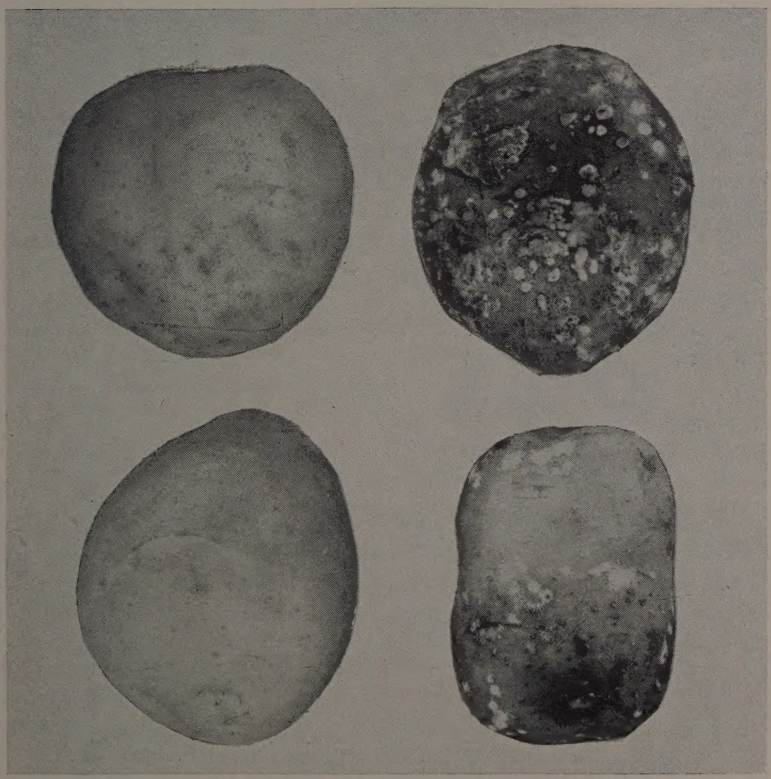

FIGURE 5. Resistance of tubers to late blight rot. Sound tubers are of Sebago and 336-18; decayed tubers are Katahdin and Green Mountain. All were harvested under conditions favorable for the development of tuber rot.

Although under the conditions of these tests the tubers of the blight-resistant varieties did not develop late-blight tuber rot, the authors and others have found that injured tubers of resistant varieties may contract the disease. However, experience in Maine has shown that tubers of blight-resistant varieties have not developed late-blight tuber rot in the field and rarely have contracted the disease in the process of harvesting. Blight-susceptible varieties developed considerable tuber rot under the same conditions.

TABLE 5

*Comparison of Late-Blight Tuber Rot in Susceptible and Resistant Varieties Resulting from Natural Infection*

| Year of test | Variety | Late-blight tuber rot[1] |
|---|---|---|
| | | Per cent |
| 1936 | Green Mountain | 52 |
| | Sebago | 0 |
| 1937 | Green Mountain | 26 |
| | Sebago | 0 |
| 1938 | Green Mountain | 10 |
| | Sebago | 0 |
| | S 336-18 | 0 |
| | Saranac | 0 |
| | President | 0 |
| 1945 | Katahdin | 24 |
| | Saranac | 0 |
| 1947 | Katahdin | 50 |
| | Green Mountain | 55 |
| | Sebago | 0 |
| | Kennebec | 0 |

[1] Late blight was permitted to develop in the foliage and the crop was harvested while the foliage was still green.

## DISCUSSION AND CONCLUSIONS

Losses from late-blight tuber rot occur nearly every year in the potato growing areas of Maine. Much of this tuber rot is the result of harvesting the crop while the fungus is still alive and before the plants are completely dead. Many farmers do not detect this disease if it is present in small amounts on the partially dead stalks and leaves, or they consider that such a light infection of blight will cause no loss. Actually a light infection on the foliage may cause a great deal of tuber decay in the bin. The freshly dug tubers become inoculated with the late-blight spores in the process of digging the crop. The amount of tuber rot may be greatly reduced by delaying harvesting until the plants have been killed by frost.

Potato growers generally are very anxious to harvest their crop as early as possible in the fall and often do not wait until the vines are dead from natural causes. When late blight is present, the potato tops should be killed by spraying with an herbicide or using a rotobeater, or the harvesting should be delayed until the foliage is dead as a result of maturity or killed by frost. The danger from late-blight tuber rot, resulting from harvesting of infected immature potato vines, may be increased by the more general use of DDT. The application of this material delays the maturity of the potato plants and thereby may increase the danger from infection. Any herbicide that is toxic enough to kill the potato foliage will destroy the late-blight fungus and prevent tuber decay.

Some farmers spray the infected potato foliage with a concentrated solution of copper sulphate for the purpose of reducing the amount of late-blight tuber infection. This practice kills the viable spores on the surface of the living plants and thus may reduce the amount of rot if the potatoes are harvested soon after the spray has been applied. However, the fungus will produce new spores when the conditions are favorable which may infect the potato tubers when they are dug. Therefore digging should be done very soon after the field has been sprayed with copper sulphate solution in order to make certain new late blight spores will not develop and cause tuber rot in the bin.

It was determined that the rotobeater, which destroys the foliage by mechanical means, was an aid in reducing the amount of late-blight decay. This machine, however, does not kill all of the foliage and that which remains may be a source of infection during favorable conditions.

Under the moderately favorable conditions for late blight that prevailed during the test with the rotobeater late-blight tuber rot was controlled about as well by foliage destruction with the rotobeater as with the rotobeater followed with an herbicide. Under more severe late-blight conditions it might be advisable to use an herbicide following the use of the rotobeater to insure the most effective control of late-blight tuber rot.

Late-blight tuber rot can be controlled by growing resistant varieties. The resistant varieties used in the reported experiments did not develop late-blight rot. In contrast, a high percentage of rot did develop in the susceptible Green Mountain and Katahdin varieties grown under the same conditions. The Sebago variety, although only moderately resistant in the foliage, did not develop storage rot during the four years it was tested. These results confirm the statements made

by Maine growers and home gardeners that this variety does not rot even under conditions favorable for blight development.

Akeley *et al.* (*2*) recently described the Kennebec variety, which is highly resistant to both foliage and tuber infection. This variety showed no tuber decay in the authors' test plots in 1947, in which 50 and 55 per cent tuber infection resulted in the Katahdin and Green Mountain varieties, respectively.

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